Having illustrated and described the principles of our invention in a preferred embodiment thereof, it should be readily apparent to those skilled in the art that the invention can be modified in arrangement and detail without departing from such principles. We claim all modifications coming within the spirit and scope of the accompanying claims.

What is claimed is:

1. A compound objective lens, comprising:

lens means, having a first convex surface and a second convex surface opposite to each other, for receiving a beam of incident light of one particular wavelength passing through an optical axis at the first convex surface, refracting the beam of incident light and emitting a beam of refracted light from the second convex surface; and

plural focal point generating means for receiving the beam of incident light not yet refracted by the lens means, generating from the beam of incident light a plurality of beams of divided light including a first beam of divided light and a second beam of divided light, converging the beams of divided light at a plurality of focal points which are placed on the optical axis on a side facing the second convex surface of the lens means on condition that the first beam of divided light transmits through a first substrate and is converged on an information recording plane placed at a first distance T1 from a surface of the first substrate at a diffraction limit and that the second beam of divided light transmits through a second substrate and is converged on an information recording plane placed at a second distance T2 ($T1 \neq T2$) from a surface of the second substrate at a diffraction limit.

2. A compound objective lens according to claim 1 in which the plural focal point generating means is a hologram generating from the incident light as the beams of divided light a plurality of beams of diffracted light having different diffraction orders.

3. A compound objective lens according to claim 2 in which the first beam of divided light is a beam of transmitted light which agrees with a beam of zero-order diffracted light generated by the hologram, and the second beam of divided light is a beam of first-order diffracted light generated by the hologram.

4. A compound objective lens according to claim 2 in which

the hologram is a phase modulation relief type of diffraction device,

a grating pattern of the hologram has a step-wise cross section and is formed in a concentric circle shape,

the grating pattern of the hologram is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through the grating pattern of the hologram varies in a step-wise shape of four stairs for each of the blocks, and

a ratio of an etching width of a top stair to a length of the corresponding block and another ratio of an etching width of a bottom stair to the length of the corresponding block are respectively lowered toward an outer direction of the grating pattern of the hologram.

5. A compound objective lens according to claim 2 in which the hologram is a phase modulation relief type of diffraction device,

a grating pattern of the hologram is formed in a concéntric circle shape and is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through an inner portion of the grating pattern of the hologram varies in a step-wise shape of four inside stairs for each of the blocks,

the four inside stairs are composed of a top stair, a second stair, a third stair and a bottom stair in that order,

a ratio of an etching width of the top stair to a length of the corresponding block and another ratio of an etching width of the bottom stair to the length of the corresponding block are respectively lowered toward an outer direction of the grating pattern in the inner portion of the hologram,

another phase modulation degree of the incident light passing through an outer portion of the grating pattern of the hologram varies in a step-wise shape of two outside stairs for each of the blocks, and

a difference in width between the outside stairs is increased toward the outer direction of the grating pattern in the outer portion of the hologram.

6. A compound objective lens according to claim 2 in which

the hologram is a phase modulation relief type of diffraction device,

a grating pattern of the hologram has a step-wise cross section and is formed in a concentric circle shape,

the grating pattern of the hologram is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through the grating pattern of the hologram varies in a step-wise shape of four stairs for each of the blocks, and

a ratio of an etching width of a top stair to a length of the corresponding block and another ratio of an etching width of a bottom stair to the length of the corresponding block are respectively lowered toward an inner direction of the grating pattern of the hologram.

7. A compound objective lens according to claim 2 in which

the hologram is a phase modulation relief type of diffraction device,

a grating pattern of the hologram is formed in a concentric circle shape and is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through an outer portion of the grating pattern of the hologram varies in a step-wise shape of four inside stairs for each of the blocks,

the four inside stairs are composed of a top stair, a second stair, a third stair and a bottom stair in that order,

a ratio of an etching width of the top stair to a length of the corresponding block and another ratio of an etching width of the bottom stair to the length of the corresponding block are respectively lowered toward an inner direction of the grating pattern in the outer portion of the hologram,

another phase modulation degree of the incident light passing through an inner portion of the grating pattern of the hologram varies in a step-wise shape of two inside stairs for each of the blocks, and

a difference in width between the inside stairs is increased toward the inner direction of the grating pattern in the inner portion of the hologram.

8. A compound objective lens according to claim 2 in which the hologram is a phase modulation type of diffraction device and is made of a liquid crystal cell.

9. A compound objective lens according to claim 2 in which the hologram is a phase modulation type of diffraction device and is placed on a substrate of a birefringence material.

10. A compound objective lens according to claim 2 in which a positional relationship between the lens means and the hologram is fixed.

11. A compound objective lens according to claim 10 in which the hologram is formed on a lens surface of the lens means.

12. A compound objective lens according to claim 11 in which the hologram is placed on a lens surface of the lens means of which a curvature is higher than those of other lens surfaces of the lens means.

13. A compound objective lens according to claim 11 in which the hologram is placed on a lens surface of the lens means of which a curvature is lower than those of other lens surfaces of the lens means.

14. A compound objective lens according to claim 1 in which a numerical aperture of the lens means for the incident light converged at one focal point of the focal points differs from that for the incident light converged at another focal point of the focal points.

15. A compound objective lens according to claim **2** in which a grating pattern is formed in a first portion of a light-passing area of the hologram corresponding to an aperture of the lens means, and any grating pattern is not formed in a second portion of the light-passing area of the hologram.

16. A compound objective lens according to claim **15** in which a phase of the incident light passing through the second portion of the light-passing area of the hologram almost agrees with an average value of phases of the incident light passing through the first portion of the light-passing area of the hologram.

17. A compound objective lens according to claim **15** in which the grating pattern is formed in a step-wise shape having a plurality of stairs,

a surface height of the second portion of the light-passing area of the hologram in an optical direction is the same as a height of a stair selected from the stairs except a top stair and a bottom stair.

18. A compound objective lens according to claim **1** in which a numerical aperture of the lens means is equal to or higher than 0.6.

* * * * *

19. A compound objective lens according to claim 1 in which the focal points of the beams of divided light generated by the plural focal point generating means correspond to focal positions differing from each other in an optical axis direction.

20. A compound objective lens according to claim 1 in which two focal points selected from among the focal points of the beams of divided light generated by the plural focal point generating means correspond to two different positions from one of the first and second substrates.

21. A compound objective lens according to claim 2 in which a numerical aperture of the lens means for the incident light converged at one focal point of the focal points differs from that for the incident light converged at another focal point of the focal points.

22. A compound objective lens according to claim 2 in which the focal points generated by the hologram correspond to focal positions differing from each other in an optical axis direction.

23. A compound objective lens according to claim 2 in which two focal points selected from among the focal points correspond to two positions placed far from a substrate at two different thicknesses.

24. A compound objective lens according to claim 2 in which a numerical aperture of the lens means is equal to or higher than 0.6.

25. An image optical system, comprising:

a light source for radiating a beam of incident light of one particular wavelength; λ_1

lens means, having a first convex surface and a second convex surface opposite to each other, for receiving the beam of incident light, which is radiated from the light source and passes through an optical axis, at the first convex surface, refracting the beam of incident light and emitting a beam of refracted light from the second convex surface; and

plural focal point generating means for receiving the beam of incident light not yet refracted by the lens means, generating from the beam of incident light a plurality of beams of divided light including a first beam of divided light and a second beam of divided light, converging the beams of divided light at a plurality of focal points which are placed on the optical axis on a side facing the second convex surface of the lens means on condition that the first beam of divided light transmits through a first substrate and is converged on an information recording plane placed at a first distance T1 from a surface of the first substrate at a diffraction limit and that the second beam of divided light transmits through a second substrate and is converged on an information recording plane placed at a second distance T2 ($T1 \neq T2$) from a surface the second substrate at a diffraction limit.

26. An image optical system according to claim 25 in which the plural focal point generating means is a hologram.

27. An image optical system according to claim 26 in which a plurality of beams of diffracted light having different diffraction orders are generated from the incident light in the hologram, and the beams of the diffracted light are converged at the focal points in one-to-one correspondence.

28. An image optical system according to claim 27 in which a beam of transmitted light which agrees with a beam of zero-order diffracted light generated by the hologram is converged at a first focal point of the focal points, and a beam of diffracted light generated by the hologram is converged at a second focal point of the focal points.

29. An image optical system according to claim 26 in which a grating pattern is formed in the hologram in a concentric circle shape.

30. A compound objective lens according to claim 26 in which a positional relationship between the lens means and the hologram is fixed.

31. An image optical system according to claim 30 in which the hologram is formed on a lens surface of the lens means.

32. An image optical system according to claim 31 in which the hologram is placed on a lens surface of the lens means which has a higher curvature than those of other lens surfaces of the lens means and is placed at a position nearer than those of the other lens surfaces of the lens means.

33. An image optical system according to claim 31 in which the hologram is placed on a lens surface of the lens means which has a lower curvature than those of other lens surfaces of the lens means and is placed at an opposite position of the lens means from the light source.

34. An image optical system according to claim 25 in which a numerical aperture of the lens means for the incident light converged at one focal point of the focal points differs from that for the incident light converged at another focal point of the focal points.

35. An image optical system according to claim 34 in which the plural focal point generating means is a hologram.

36. An image optical system according to claim 35 in which a grating pattern is formed in a first portion of a light-passing area of the hologram corresponding to an aperture of the lens means, and any grating pattern is not formed in a second portion of the light-passing area of the hologram.

37. An image optical system according to claim 36 in which a phase of the incident light passing through the second portion of the light-passing area of the hologram almost agrees with an average value of phases of the incident light passing through the first portion of the light-passing area of the hologram.

38. An image optical system according to claim 35 in which a first diffraction efficiency of the hologram at a first region for the incident light differs from a second diffraction efficiency of the hologram at a second region for the incident light.

39. An image optical system according to claim 25 in which a far field pattern of the incident light radiated from the light source is distributed to decrease an intensity of the incident light toward a peripheral portion of the beam,

an intensity of the incident light passing through a central portion of the lens means is two or more times that of the incident light passing through a peripheral portion of the lens means.

40. An image optical system according to claim 25 in which the focal points generated by the plural focal point generating means correspond to focal positions differing from each other in an optical axis direction.

41. An image optical system according to claim 40 in which the plural focal point generating means is a hologram.

42. An image optical system according to claim 25 in which two focal points selected from among the focal points correspond to two positions placed far from a substrate at two different thicknesses.

43. An image optical system according to claim 42 in which the plural focal point generating means is a hologram.

44. An optical head apparatus, comprising:

a light source for radiating a beam of incident light of one particular wavelength;

lens means, having a first convex surface and a second convex surface opposite to each other, for receiving the beam of incident light, which is radiated from the light source and passes through an optical axis, at the first convex surface, refracting the beam of incident light and emitting a beam of refracted light from the second convex surface; and

plural focal point generating means for receiving the beam of incident light not yet refracted by the lens means, generating from the beam of incident light a plurality of beams of divided light including a first beam of divided light and a second beam of divided light, converging the beams of divided light at a plurality of focal points which are placed on the optical axis on a side facing the second convex surface of the lens means on condition that the first beam of divided light transmits through a first substrate and is converged on an information recording plane placed at a first distance T1 from a surface of the first substrate at a diffraction limit and that the second beam of divided light transmits through a second substrate and is converged on an information recording plane placed at a second distance T2 ($T1 \neq T2$) from a surface of the second substrate at a diffraction limit; and

a photo detector for receiving a plurality of beams of reflected light obtained by reflecting the beams of divided light converged on the information recording planes of the substrates by the plural focal point generating means and outputting an electric signal generated according to intensities o f the beams of reflected light.

45. An optical head apparatus according to claim 44 in which the plural focal point generating means is a hologram.

46. An optical head apparatus according to claim 45 in which a plurality of beams of diffracted light having different diffraction orders are generated from the incident light in the hologram, and the beams of the diffracted light are converged at the focal points in one-to-one correspondence.

47. An optical head apparatus according to claim 46 in which a beam of transmitted light which agrees with a beam of zero-order diffracted light generated by the hologram is converged at a first focal point of the focal points, and a beam of diffracted light generated by the hologram is converged at a second focal point of the focal points.

48. An optical head apparatus according to claim 45 in which a grating pattern is formed in the hologram in a concentric circle shape.

49. An optical head apparatus according to claim 48 in which the grating pattern is formed in a first portion of a light-passing area of the hologram corresponding to an aperture of the lens means, and another grating pattern is non-concentrically formed in a second portion of the light-passing area of the hologram to diffract the incident light.

50. An optical head apparatus according to claim 45 in which the hologram is a phase modulation type of diffraction device.

51. An optical head apparatus according to claim 50 in which a phase modulation degree of light passing through the hologram is lower than 2π radians.

52. An optical head apparatus according to claim 50 in which the hologram is a relief type of diffraction device.

53. An optical head apparatus according to claim 52 in which a height H of relief formed in the hologram is set to:

$$H < \lambda/(n(\lambda)-1),$$

where a symbol λ denotes a wavelength of the incident light and a symbol $n(\lambda)$ denotes a refractive index of a material of the hologram for the incident light having the wavelength λ, and

a difference in phase modulation degree of the incident light passing through the hologram is lower than 2π radians.

54. An optical head apparatus according to claim 52 in which a grating pattern of the hologram is formed in a step-wise cross sectional shape.

55. An optical head apparatus according to claim 54 in which the grating pattern of the hologram is formed in a concentric circle shape and is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through the grating pattern of the hologram varies in a step-wise shape of four stairs for each of blocks, and

a ratio of an etching width of a top stair to a length of the block and another ratio of an etching width of a bottom stair to the length of the block are respectively lowered toward an outer direction of the grating pattern of the hologram.

56. An optical head apparatus according to claim 54 in which the grating pattern of the hologram is formed in a concentric circle shape and is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through an inner portion of the grating pattern of the hologram varies in a step-wise shape of four inside stairs for each of blocks,

the four inside stairs are composed of a top stair, a second stair, a third stair and a bottom stair in that order,

a ratio of an etching width of a top stair to a length of the block and another ratio of an etching width of a bottom stair to the length of the block are respectively lowered toward an outer direction of the grating pattern in the inner portion of the hologram,

another phase modulation degree of the incident light passing through an outer portion of the grating pattern of the hologram varies in a step-wise shape of two outside stairs for each of blocks,

a height of an upper stair of the outside stairs agrees with that of the second stair,

a height of a lower stair of the outside stairs agrees with that of the third stair, and

a difference in width between the upper and lower stairs is increased toward the outer direction of the grating pattern in the outer portion of the hologram.

57. An optical head apparatus according to claim 54 in which the grating pattern of the hologram is formed in a concentric circle shape and is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through the grating pattern of the hologram varies in a step-wise shape of four stairs for each of blocks, and

a ratio of an etching width of a top stair to a length of the block and another ratio of an etching width of a bottom stair to the length of the block are respectively lowered toward an inner direction of the grating pattern of the hologram.

58. An optical head apparatus according to claim 54 in which the grating pattern of the hologram is formed in a concentric circle shape and is concentrically partitioned into a plurality of blocks,

a phase modulation degree of the incident light passing through an outer portion of the grating pattern of the hologram varies in a step-wise shape of four outside stairs for each of blocks,

the four outside stairs are composed of a top stair, a second stair, a third stair and a bottom stair in that order,

a ratio of an etching width of a top stair to a length of the block and another ratio of an etching width of a bottom stair to the length of the block are respectively lowered toward an inner direction of the grating pattern in the outer portion of the hologram,

another phase modulation degree of the incident light passing through an inner portion of the grating pattern of the hologram varies in a step-wise shape of two inside stairs for each of blocks,

a height of an upper stair of the inside stairs agrees with that of the second stair,

a height of a lower stair of the inside stairs agrees with that of the third stair, and

a difference in width between the upper and lower stairs is increased toward the inner direction of the grating pattern in the inner portion of the hologram.

59. An optical head apparatus according to claim 50 in which the hologram a phase modulation type of diffraction device made of a liquid crystal cell.

60. An optical head apparatus according to claim 50 in which the hologram means is a phase modulation type of diffraction device placed on a substrate made of a birefringence material.

61. An optical head apparatus according to claim 45 in which the hologram is arranged on a plane, and an optical axis of the lens means is not in parallel with a normal line of the plane.

62. An optical head apparatus according to claim 45 in which a positional relationship between the lens means and the hologram is fixed.

63. An optical head apparatus according to claim 62 in which the hologram is formed on a lens surface of the lens means.

64. An optical head apparatus according to claim 63 in which the hologram is placed on a lens surface of the lens means of which a curvature is higher than those of other lens surfaces of the lens means.

65. An optical head apparatus according to claim 63 in which the hologram is placed on a lens surface of the lens means of which a curvature is lower than those of other lens surfaces of the lens means.

66. An optical head apparatus according to claim 44 in which a numerical aperture of the lens means for the incident light converged at one focal point of the focal points differs from that for the incident light converged at another focal point of the focal points.

67. An optical head apparatus according to claim 66 in which the plural focal point generating means is a hologram.

68. An optical head apparatus according to claim 67 in which a grating pattern is formed in a first portion of a light-passing area of the hologram corresponding to an aperture of the lens means, and any grating pattern is not formed in a second portion of the light-passing area of the hologram.

69. An optical head apparatus according to claim 68 in which a phase of the incident light passing through the second portion of the light-passing area of the hologram almost agrees with an average value of phases of the incident light passing through the first portion of the light-passing area of the hologram.

70. An optical head apparatus according to claim 68 in which the grating pattern is formed in a step-wise shape having a plurality of stairs,

a surface height of the second portion of the light-passing area of the hologram in an optical axis direction is the same as a height of a stair selected from the stairs except a top stair and a bottom stair.

71. An optical head apparatus according to claim 67 in which a first diffraction efficiency of the hologram at a first region for the incident light differs from a second diffraction efficiency of the hologram at a second region for the incident light.

72. An optical head apparatus according to claim 71 in which a grating pattern of the hologram is concentrically formed, the hologram is a phase modulation type of diffraction device, and a phase modulation degree in an outer portion of the grating pattern of the hologram is lower than that in an inner portion of the grating pattern of the hologram.

73. An optical head apparatus according to claim 71 in which a grating pattern of the hologram is concentrically formed, the hologram is a phase modulation type of diffraction device, and a phase modulation degree in an inner portion of the grating pattern of the hologram is lower than that in an outer portion of the grating pattern of the hologram.

74. An optical head apparatus according to claim 44 in which a far field pattern of the incident light radiated from the light source is distributed to decrease an intensity of the incident light toward a peripheral portion of the beam,

an intensity of the incident light passing through a central portion of the lens means is two or more times that of the incident light passing through a peripheral portion of the lens means.

75. An optical head apparatus according to claim 44 in which the focal points generated by the plural focal point generating means correspond to focal positions differing from each other in an optical axis direction.

76. An optical head apparatus according to claim 75 in which the plural focal point generating means is a hologram.

77. An optical head apparatus according to claim 44 in which two focal points selected from among the focal points correspond to two positions placed inside a substrate at two different thicknesses.

78. An optical head apparatus according to claim 77 in which the plural focal point generating means is a hologram.

79. An optical head apparatus according to claim 78 in which the lens means converges a beam of transmitted light obtained by passing the incident light through the hologram on an information recording plane placed far from a substrate surface by a first thickness T1, and the hologram converges a beam of diffracted light obtained by diffracting the incident light in the hologram and refracting the incident light in the lens means on another information recording plane placed far from the substrate surface by a second thickness T2 (T1<T2).

80. An optical head apparatus according to claim 78 in which the hologram converges a beam of diffracted light

obtained by diffracting the incident light in the hologram and refracting the incident light in the lens means on another information recording plane placed far from the substrate surface by a first thickness T1, and the lens means converges a beam of transmitted light obtained by passing the incident light through the hologram on an information recording plane placed far from a substrate surface by a second thickness T2 (T1<T2).

81. An optical head apparatus according to claim 44 in which the photo detector is arranged close to the light source.

82. An optical head apparatus according to claim 44 in which the incident light linearly polarized is radiated from the light source, and

the optical head apparatus, further comprising:

a polarized beam splitter for totally transmitting a beam of light linearly polarized in a first direction and totally reflecting a beam of light linearly polarized at a second direction perpendicular to the first direction; and

a 1/4-λ plate for changing the light transmitting through or reflected by the polarized beam splitter to a beam of light circularly polarized in a rotational direction, wherein the incident light linearly polarized in a third direction agreeing with the first or second direction is circularly polarized in a first rotational direction by the 1/4-λ plate, the light circularly polarized in the first rotational direction is converged on the information mediums by the lens means and the plural focal point generating means to form a beam of light circularly polarized in a second rotational direction opposite to the first rotational direction, the light circularly polarized in the second rotational direction is changed to the light linearly polarized in a fourth direction perpendicular to the first direction by the 1/4-λ plate, and the light linearly polarized in the fourth direction is totally reflected by or transmits through the polarized beam splitter to be incident on the photo detector.

83. An optical head apparatus according to claim 44 in which the photo detector comprises:

a servo signal detector for detecting a servo signal included in one of the reflected light; and

another signal detector arranged at a periphery of the servo signal detector for detecting another signal included in another one of the reflected light.

84. An optical head apparatus according to claim 44 in which the photo detector comprises:

a signal detector for detecting a focus error signal and a tracking error signal included in the reflected light.

85. An optical head apparatus according to claim 44, further comprising:

reshaping means for reshaping the incident light radiated from the light source, the incident light reshaped being refracted by the lens means.

86. An optical disk, comprising:

an information recording substrate partitioned into a first region and a second region, the first region having a first thickness T1, and the second region having a second thickness T2 larger than the first thickness T1;

a plurality of first recording pits placed at the first region of the information recording substrate for recording

pieces of recording information at a high recording density; and

a plurality of second recording pits placed at the second region of the information recording substrate for recording pieces of distinguishing information at an ordinary recording density which is lower than the high recording density, the distinguishing information informing that the first region of the information recording substrate has the first thickness T1.

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87. An optical disk, comprising:

an information recording substrate having a thin thickness, the thin thickness of the information recording substrate being thinner than that of a compact disk;

a plurality of first recording pits placed at a first region of the information recording substrate for recording pieces of recording information at a high recording density; and

a plurality of second recording pits placed at a second region of the information recording substrate for recording pieces of distinguishing information at a low recording density, the distinguishing information informing that the first region of the information recording substrate has the thin thickness.

Sub C1

88. An optical disk apparatus, comprising:

rotating means for rotating an information medium which has a first thickness T1 or a second thickness T2 larger than the first thickness T1;

an optical head apparatus having an objective lens for reading an information signal, a focus error signal and a tracking error signal from the information medium rotated by the rotating means through the objective lens;

moving means for moving the optical head apparatus;

connecting means for connecting the rotating means and the moving means with an electric source to supply an electric power to the rotating means and the moving means;

actuating means for actuating the objective lens of the optical head apparatus;

focus control means for controlling the actuating means to perform a first focus control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the focus error signal read by the optical head apparatus;

tracking control means for controlling the actuating means to perform a first tracking control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the tracking error signal read by the optical head apparatus;

detecting means for detecting whether the information medium has the first thickness T1 or the second thickness T2; and

changing means for switching from the second focus and tracking controls performed by the focus control means and the tracking control means to the first focus and tracking controls performed by the focus control means and the tracking control means according to the detection of the detecting means.

89. An optional disk apparatus according to claim 88 in which the second focus control and the second tracking control corresponding to the second thickness T2 are performed by the focus control means and the tracking control means, a piece of distinguishing information informing the thickness of the information medium is detected by he detecting means, and the focus control means and the tracking control means perform the first focus control and the first tracking control corresponding to the first thickness T1 under the control of the changing means in case where the distinguishing information informs that the information medium has the first thickness T1.

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90. An optical disk apparatus according to claim 88 in which the second focus control and the second tracking control corresponding to the second thickness T2 are performed by the focus control means and the tracking control means to read an information signal recorded in the information medium, and the focus control means and the tracking control means perform the first focus control and the first tracking control corresponding to the first thickness T1 under the control of the changing means in case where an intensity of the information signal is less than a constant value.

91. An optical disk apparatus according to claim 88 in which an optical head apparatus has a plurality of focal points.

Sub C2

92. An optical disk apparatus, comprising:

rotating means for rotating an information medium which has a first thickness T1 or a second thickness T2 larger than the first thickness T1;

an optical head apparatus having an objective lens for converging a beam of incident light at a plurality of focal points and reading an information signal, a focus error signal and a tracking error signal from the information medium rotated by the rotating means;

moving means for moving the optical head apparatus;

connecting means for connecting the rotating means and the moving means with an electric source to supply an electric power to the rotating means and the moving means;

actuating means for actuating the objective lens of the optical head apparatus;

focus control means for controlling the actuating means to perform a first focus control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the focus error signal read by the optical head apparatus; and

tracking control means for controlling the actuating means to perform a first tracking control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the tracking error signal read by the optical head apparatus.

Sub C3

93. An optical disk apparatus according to claim 92 in which the objective lens of the optical head apparatus is moved in a direction to the information medium by the moving means, and the objective lens of the optical head

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apparatus is focused on the information medium by the actuating means under the control of the focus control means to decrease an intensity of the focus error signal to zero in case where the intensity of the focus error signal exceeds a threshold.

94. An optical disk apparatus according to claim 92 in which the optical head apparatus comprises:

the objective lens for refracting the incident light; and

a hologram for converging the incident light refracted by the lens means at a plurality of focal points which are placed at one side of the lens means.

95. An optical disk apparatus according to claim 94 in which a plurality of beams of diffracted light having different diffraction orders are generated from the incident light in the hologram, and the beams of the diffracted light are converged at the focal points in one-to-one correspondence.

96. An optical disk apparatus according to claim 95 in which a beam of transmitted light which agrees with a beam of zero-order diffracted light generated by the hologram is converged at a first focal point of the focal points, and a beam of diffracted light generated by the hologram is converged at a second focal point of the focal points.

97. An optical disk apparatus according to claim 94 in which a positional relationship between the lens means and the hologram is fixed.

98. An optical disk apparatus according to claim 97 in which the hologram is formed on a lens surface of the lens means.

99. An optical disk apparatus according to claim 92 in which a numerical aperture of the optical head apparatus for a beam of light converged at one focal point of the focal points differs from that for another focal point of the focal points.

100. An optical disk apparatus according to claim 99 in which the optical head apparatus comprises:

lens means for refracting the incident light; and

hologram for converging the incident light refracted by the lens means at a plurality of focal points which are placed at one side of the lens means.

101. An optical disk apparatus according to claim 92 in which the focal points of the optical head apparatus correspond to focal positions differing from each other in an optical axis direction.

102. An optical disk apparatus according to claim 101 in which the optical head apparatus comprises:

lens means for refracting the incident light; and

a hologram for converging the incident light refracted by the lens means at a plurality of focal points which are placed at one side of the lens means.

103. An optical disk apparatus according to claim 92 in which two focal points selected from among the focal points correspond to two positions placed far from a substrate at two different thicknesses.

104. An optical disk apparatus according to claim 103 in which the optical head apparatus comprises:

lens means for refracting the incident light; and

hologram for converging the incident light refracted by the lens means at a plurality of focal points which are placed at one side of the lens means.

105. An information reproducing method comprising the steps of:

radiating a beam of incident light from a light source;

refracting the incident light radiated from the light source by lens means;

converging the incident light refracted by the lens means at a plurality of focal points which are placed at an opposite side of the lens means from the light source to form a plurality of micro spots on a plurality of information mediums placed inside a substrate at different thicknesses;

receiving a plurality of beams of reflected light obtained by reflecting the incident light converged on the information mediums;

reproducing a plurality of information signals recorded in the information mediums according to intensities of the reflected light.

106. A microscope comprising:

lens means having a plurality of focal points;

an ocular lens for receiving a beam of light from a plurality of planes through the lens means and observing the planes, the planes being placed at a plurality of positions different in an optical axis direction.

107. A microscope comprising:

lens means having a plurality of focal points;

photographing means for receiving beam of light from a plurality of planes through the lens means and photographing the planes, the planes being placed at a plurality of positions different in an optical axis direction.

108. An exposing apparatus comprising:

an alignment light source for radiating a plurality of beams of alignment light to illuminate a photomask and a sample placed at different points in an optical axis direction;

lens means for refracting the alignment light generated by the light source and diverging from the photomask and the sample;

light superposing means for superposing the alignment light refracted by the lens means to form a beam of superposed light;

ocular lens for converging the superposed light generated by the light superposing means;

aligning means for aligning the photomask and the sample according to the superposed light photographed by the photographing means;

an exposure light for radiating a beam of exposure light; and

exposing means for exposing a photo sensitive material coated on the sample which is aligned with the photomask by the aligning means.

109. An exposing apparatus comprising:

an alignment light source for radiating a plurality of beams of alignment light to illuminate a photomask and a sample placed at different points in an optical axis direction;

lens means for refracting the alignment light generated by the light source and diverging from the photomask and the sample;

light superposing means for superposing the alignment light refracted by the lens means to form a beam of superposed light;

photographing means for photographing the superposed light generated by the light superposing means;

aligning means for aligning the photomask and the sample according to the superposed light converged by the ocular lens;

an exposure light source for radiating a beam of exposure light; and

exposing means for exposing a photo sensitive material coated on the sample which is aligned with the photomask by the aligning means to the exposure light radiated from the exposure light source.

110. An image reproducing apparatus, comprising:

rotating means for rotating an information medium which has a first thickness T1 or a second thickness T2 larger than the first thickness T1;

an optical head apparatus having an objective lens for converging a beam of incident light at a plurality of focal points and reading an image information signal, a focus error signal and a tracking error signal from the information medium rotated by the rotating means;

moving means for moving the optical head apparatus;

connecting means for connecting the rotating means and the moving means with an electric source to supply an electric power to the rotating means and the moving means;

actuating means for actuating the objective lens of the optical head apparatus;

focus control means for controlling the actuating means to perform a first focus control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the focus error signal read by the optical head apparatus;

tracking control means for controlling the actuating means to perform a first tracking control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the tracking error signal read by the optical head apparatus; and

displaying means for reproducing the image information signal read by the optical head apparatus as an image.

111. A voice reproducing apparatus, comprising:

rotating means for rotating an information medium which has a first thickness T1 or a second thickness T2 larger than the first thickness T1;

an optical head apparatus having an objective lens for converging a beam of incident light at a plurality of focal points and reading a voice information signal, a focus error signal and a tracking error signal from the information medium rotated by the rotating means;

moving means for moving the optical head apparatus;

connecting means for connecting the rotating means and the moving means with an electric source to supply an electric power to the rotating means and the moving means;

actuating means for actuating the objective lens of the optical head apparatus;

focus control means for controlling the actuating means to perform a first focus control of the optical head apparatus corresponding to the first thickness Tl of the information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the focus error signal read by the optical head apparatus;

tracking control means for controlling the actuating means to perform a first tracking control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the tracking error signal read by the optical head apparatus; and

voice reproducing means for reproducing the voice information signal read by the optical head apparatus as voices.

112. An information processing apparatus, comprising:

rotating means for rotating an information medium which has a first thickness T1 or a second thickness T2 larger than the first thickness T1;

an optical head apparatus having an objective lens for converging a beam of incident light at a plurality of focal points and reading an information signal, a focus error signal and a tracking error signal from the information medium rotated by the rotating means;

moving means for moving the optical head apparatus;

connecting means for connecting the rotating means and the moving means with an electric source to supply an electric power to the rotating means and the moving means;

actuating means for actuating the objective lens of the optical head apparatus;

focus control means for controlling the actuating means to perform a first focus control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the focus error signal read by the optical head apparatus;

tracking control means for controlling the actuating means to perform a first tracking control of the optical head apparatus corresponding to the first thickness T1 of the information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the information medium according to the tracking error signal read by the optical head apparatus; and

information processing means for processing the information signal read by the optical head apparatus as an image.

113. An optical head apparatus, comprising:

a light source for radiating a beam of incident light;

a first optical disk having a transparent substrate of a first thickness Tl and an information recording plane;

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a second optical disk having a transparent substrate of a second thickness T2 lower than the first thickness Tl (T2<Tl) and an information recording plane;

an objective lens, partitioned into a plurality of light passing regions including a first light passing region and a second light passing region respectively corresponding to a distance from an optical axis of the beam of incident light radiated from the light source, for receiving the beam of incident light radiated from the light source, converging the beam of incident light, which passes through the second light passing region and the transparent substrate of the second optical disk, at the information recording plane of the second optical disk, and converging the beam of incident light, which passes through the first light passing region and the transparent substrate of the first optical disk, at the information recording plane of the first optical disk; and

a photo detector for detecting the beam of incident light, which is converged at the information recording plane of the first optical disk and the information recording plane of the second optical disk by the objective lens and is reflected by the first optical disk and the second optical disk, to obtain first information recorded in the information recording plane of the first optical disk and second information recorded in the information recording plane of the second optical disk.

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114. An optical head apparatus according to claim 113 in which the second light passing region of the objective lens is placed on an outer-most periphery of the objective lens corresponding to the distance furthest from the optical axis among those of the light passing regions.

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115. An optical disk apparatus, comprising:

a light source for radiating a beam of incident light;

a first optical disk having a transparent substrate of a first thickness Tl and an information recording plane;

a second optical disk having a transparent substrate of a second thickness T2 lower than the first thickness Tl (T2<Tl) and an information recording plane;

rotating means for rotating the first optical disk or the second optical disk;

an optical head apparatus, which comprises

an objective lens, partitioned into a plurality of light passing regions including a first light passing region and a second light passing region respectively corresponding to a distance from an optical axis of the beam of incident light radiated from the light source, for receiving the beam of incident light radiated from the light source, converging the beam of incident light, which passes through the second light passing region and the transparent substrate of the second optical disk, at the information recording plane of the second optical disk, and converging the beam of incident light, which passes through the first light passing region and the transparent substrate of the first optical disk, at the information recording plane of the first optical disk; and

a photo detector for detecting the beam of incident light which is converged at the information recording plane of the first optical disk or the information recording plane of the second optical disk by the objective lens and is reflected by the first optical disk or the second optical disk;

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focus control means for performing a first focus control of the optical head apparatus corresponding to the first thickness T1 of the first optical disk and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the second optical disk according to the beam of incident light detected by the photo detector;

tracking control means for performing a first tracking control of the optical head apparatus corresponding to the first thickness T1 of the first optical disk and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the second optical disk according to the beam of incident light detected by the photo detector; and

information detecting means for judging according to the beam of incident light detected by the photo detector of the optical head apparatus, for which the first focus control and the second focus control of the focus control means and the first tracking control and the second tracking control of the tracking control means are performed, whether the beam of incident light radiated from the light source is converged at the information recording plane of the first optical disk or the information recording plane of the second optical disk, reproducing first information recorded in the information recording plane of the first optical disk from the beam of incident light detected by the photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the first optical disk, and reproducing second information recorded in the information recording plane of the second optical disk from the beam of incident light detected by the photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the second optical disk, and

moving means for moving the optical head apparatus.

116. An optical head apparatus, comprising:

a laser light source for radiating a beam of incident light;

a first information medium having an information recording plane and a transparent substrate of a first thickness T1, a thickness of the first information medium being set to T1;

a second information medium having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness T1 (T2<T1), a thickness of the second information medium being set to T2; and

a light focusing optical system, in which an objective lens comprises:

a first lens region, corresponding to a numerical aperture NA1, for focusing the beam of incident light radiated from the laser light source on the information recording plane of the first information medium through the transparent substrate of the first information medium as a light spot for the purpose of reading out first information from the first information medium;

a second lens region, corresponding to a numerical aperture NA2 higher than the numerical aperture NA1 (NA1<NA2), for focusing the beam of incident light radiated from the laser light source on the information recording plane of the second information

medium through the transparent substrate of the second information medium as a light spot for the purpose of reading out second information from the second information medium; and

a third lens region which corresponds to a numerical aperture NA3 satisfying NA1≤NA3<NA2 and is unified with the second lens region of the objective lens through a discontinuous plane.

117. An optical head apparatus according to claim 116 in which

the objective lens of the light focusing optical system further comprises a fourth lens region, corresponding to the numerical aperture NA2 or a numerical aperture higher than NA2, for converging the beam of incident light radiated from the laser light source on the information recording plane of the second information medium through the transparent substrate of the second information medium as a light spot at a diffraction limit.

118. An optical head apparatus according to claim 116 in which the objective lens of the light focusing optical system further comprises a fourth lens region, corresponding to the numerical aperture NA3 or a numerical aperture lower than NA3, for converging the beam of incident light radiated from the laser light source on the information recording plane of the first information medium through the transparent substrate of the first information medium as a light spot at a diffraction limit.

119. An objective lens for an optical head apparatus, comprising:

a first lens region corresponding to a numerical aperture NAI for focusing a beam of incident light radiated from a laser light source on an information recording plane of a first information medium through a transparent substrate of the first information medium having a first thickness TI for the purpose of reading out first information from the first information medium;

a second lens region, corresponding to a numerical aperture NA2 higher than the numerical aperture NA1 (NA1<NA2), for focusing the beam of incident light radiated from the laser light source on an information recording plane of a second information medium through a transparent substrate of the second information medium having a second thickness T2 smaller than the first thickness T1 (Tl>T2) for the purpose of reading out second information from the second information medium; and

a third lens region which corresponds to a numerical aperture NA3 satisfying NA1≤NA3<NA2 and is unified with the second lens region through a discontinuous plane.

120. An objective lens for an optical head apparatus according to claim 119, further comprising:

a fourth lens region, corresponding to the numerical aperture NA2 or a numerical aperture higher than NA2, for converging the beam of incident light radiated from the laser light source on the information recording plane of the second information medium through the transparent substrate of the second information medium as a light spot at a diffraction limit.

121. An objective lens for an optical head apparatus according to claim 119, further comprising:

a fourth lens region, corresponding to the numerical aperture NA3 or a numerical aperture lower than NA3, for converging the beam of incident light radiated from the laser light source on the information recording plane of the first information medium through the transparent substrate of the first information medium as a light spot at a diffraction limit.

122. An optical disk apparatus, comprising:

a laser light source for radiating a beam of incident light;

a first information medium having an information recording plane and a transparent substrate of a first thickness Tl, a thickness of the first information medium being set to Tl;

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a second information medium having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness Tl (T2<Tl), a thickness of the second information medium being set to T2;

rotating means for rotating the first information medium or the second information medium;

an optical head apparatus, which comprises

a light focusing optical system, in which an objective lens comprises:

a first lens region, corresponding to a numerical aperture NA1, for focusing the beam of incident light radiated from the laser light source on the information recording plane of the first information medium through the transparent substrate of the first information medium as a light spot for the purpose of reading out first information from the first information medium;

a second lens region, corresponding to a numerical aperture NA2 higher than the numerical aperture NAl (NA1<NA2), for focusing the beam of incident light radiated from the laser light source on the information recording plane of the second information medium through the transparent substrate of the second information medium as a light spot for the purpose of reading out second information from the second information medium; and

a third lens region which corresponds to a numerical aperture NA3 satisfying NA1≤NA3<NA2 and is unified with the second lens region of the objective lens through a discontinuous plane;

focus control means for performing a first focus control of the optical head apparatus corresponding to the first thickness Tl of the first information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the second information medium according to the beam of incident light detected by the photo detector;

tracking control means for performing a first tracking control of the optical head apparatus corresponding to the first thickness Tl of the first information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the second information medium according to the beam of incident light detected by the photo detector; and

information detecting means for judging according to the beam of incident light detected by the photo detector of the optical head apparatus, for which the

first focus control and the second focus control of the focus control means and the first tracking control and the second tracking control of the tracking control means are performed, whether the beam of incident light radiated from the light source is converged at the information recording plane of the first information medium or the information recording plane of the second information medium, reproducing the first information recorded in the information recording plane of the first information medium from the beam of incident light detected by the photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the first information medium, and reproducing the second information recorded in the information recording plane of the second information medium from the beam of incident light detected by the photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the second information medium; and

moving means for moving the optical head apparatus.

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123. An optical head apparatus, comprising:

a light source for radiating a beam of incident light;

a first information medium having an information recording plane and a transparent substrate of a first thickness T1, a thickness of the first information medium being set to Tl;

a second information medium having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness T1 (T2<Tl), a thickness of the second information medium being set to T2;

a light focusing optical system for focusing the beam of incident light radiated from the light source on the information recording plane of the first information medium or the second information medium through the transparent substrate of the first thickness Tl or the transparent substrate of the second thickness T2, the light focusing optical system comprising:

an optical device for minimizing an aberration occurring in the beam of incident light in cases where the beam of incident light passing through the optical device transmits through the transparent substrate of the second information medium and is focused on the information recording plane of the second information medium, and

a ring-shaped band, placed on at least one surface of the optical device, for shifting a phase of the beam of incident light passing through the optical device to reduce a wavefront aberration caused by a difference between the thickness T1 of the first information medium and the thickness T2 of the second information medium in cases where the beam of incident light passing through the optical device transmits through the transparent substrate of the first information medium and is focused on the information recording plane of the first information medium; and

a photo detector for detecting the beam of incident light which is converged on the information recording plane of the first information medium or the information recording plane of the second information medium by the light focusing optical system and is reflect by the first information medium or the second information medium

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medium to reproduce information recorded in the first information medium or the second information medium.

124. An optical head apparatus, comprising:

a light source for radiating a beam of incident light;

a first information medium having an information recording plane and a transparent substrate of a first thickness Tl, a thickness of the first information medium being set to Tl;

a second information medium having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness T1 (T2<Tl), a thickness of the second information medium being set to T2;

a light focusing optical system having an optical device for receiving the beam of incident light radiated from the light source, adjusting a first region of the optical device to focus the beam of incident light passing through the first region of the optical device and the transparent substrate of the first information medium or the second information medium on the information recording plane of the first information medium or the second information medium for the purpose of the reproduction of information recorded in the first information medium or the second information medium, adjusting a second region of the optical device placed at a position further from an optical axis of the beam of incident light radiated from the light source than that of the first region of the optical device to focus the beam of incident light passing through the second region of the optical device and the transparent substrate of the second information medium on the information recording plane of the second information medium for the purpose of the reproduction of information recorded in the second information medium; and

a photo detector for detecting the beam of incident light, which is converged on the information recording plane of the first information medium or the information recording plane of the second information medium by the light focusing optical system and is reflect by the first information medium or the second information medium, to reproduce information recorded in the first information medium or the second information medium.

125. An optical head apparatus according to claim 123 in which the optical device of the light focusing optical system is an objective lens.

126. An optical head apparatus, comprising:

a light source for radiating a beam of incident light;

a first information medium having an information recording plane and a transparent substrate of a first thickness Tl a thickness of the first information medium being set to Tl;

a second information medium having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness Tl (T2<Tl), a thickness of the second information medium being set to T2;

a light focusing optical system for receiving the beam of incident light radiated from the light source and focusing the beam of incident light on the information recording plane of the first information medium or the

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second information medium through the transparent substrate of the first thickness T1 or the transparent substrate of the second thickness T2 to read out information recorded in the first information medium or the second information medium, the light focusing optical system comprising

a phase adjusting device, formed in a ring-band shape, for shifting a part of the beam of incident light radiated from the light source, and

an objective lens, having a light converging performance so as to converge the beam of incident light radiated from the light source on the information recording plane of the second information medium through the transparent substrate of the second thickness T2 at a diffraction limit, for converging the beam of incident light, of which the part is shifted by the phase adjusting device, on the information recording plane of the first information medium or the second information medium through the transparent substrate of the first thickness T1 or the transparent substrate of the second thickness T2; and

a photo detector for detecting the beam of incident light, which is converged on the information recording plane of the first information medium or the information recording plane of the second information medium by the light focusing optical system and is reflect by the first information medium or the second information medium, to reproduce information recorded in the first information medium or the second information medium.

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127. A compound objective lens, in which a beam of incident light radiated from a light source is focused on an information recording plane of a first information medium through a transparent substrate of a first thickness T1 or on an information recording plane of a second information medium through a transparent substrate of a second thickness T2 smaller than the first thickness T1 (T2<T1), comprising:

an objective lens, having a light focusing performance so as to minimize an aberration occurring in the beam of incident light in cases where the beam of incident light radiated from the light source is focused on the information recording plane of the second information medium through the transparent substrate of the second thickness T2, for focusing the beam of incident light radiated from the light source on the information recording plane of the first information medium or the second information medium through the transparent substrate of the first thickness T1 or the transparent substrate of the second thickness T2; and

a ring-shaped band, arranged at least one surface of the objective lens, for shifting a phase of a part of the beam of incident light passing through the objective lens to reduce a wave-front aberration caused by a difference between the thickness T1 of the first information medium and the thickness T2 of the second information medium in cases where the beam of incident light is focused on the information recording plane of the first information medium.

128. An optical disk apparatus, comprising:

a light source for radiating a beam of incident light;

a first information medium, having an information recording plane and a transparent substrate of

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a first thickness T1, for recording first information on the information recording plane, a thickness of the first information medium being set to T1;

a second information medium, having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness Tl (T2<Tl), for recording second information on the information recording plane, a thickness of the second information medium being set to T2;

rotating means for rotating the first information medium or the second information medium;

an optical head apparatus, which comprises

a light focusing optical system for focusing the beam of incident light radiated from the light source on the information recording plane of the first information medium or the second information medium through the transparent substrate of the first thickness T1 or the transparent substrate of the second thickness T2, the light focusing optical system comprising

an optical device for minimizing an aberration occurring in the beam of incident light in cases where the beam of incident light passing through the optical device transmits through the transparent substrate of the second information medium and is focused on the information recording plane of the second information medium, and

a ring-shaped band, placed on at least one surface of the optical device, for shifting a phase of the beam of incident light passing through the optical device to reduce a wave-front aberration caused by a difference between the thickness T1 of the first information medium and the thickness T2 of the second information medium in cases where the beam of incident light passing through the optical device transmits through the transparent substrate of the first information medium and is focused on the information recording plane of the first information medium;

focus control means for performing a first focus control of the optical head apparatus corresponding to the first thickness Tl of the first information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the second information medium according to the beam of incident light detected by the photo detector;

tracking control means for performing a first tracking control of the optical head apparatus corresponding to the first thickness Tl of the first information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the second information medium according to the beam of incident light detected by the photo detector; and

information detecting means for judging according to the beam of incident light detected by the photo detector of the optical head apparatus, for which the first focus control and the second focus control of the focus control means and the first tracking control and the second tracking control of the tracking control means are performed, whether the beam of incident light radiated from the light source is converged at the information recording plane of the first information medium or the information recording plane of the second information medium, reproducing the first information recorded in the information recording plane of the first information medium from the beam of incident light detected by the

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photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the first information medium, and reproducing the second information recorded in the information recording plane of the second information medium from the beam of incident light detected by the photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the second information medium; and

moving means for moving the optical head apparatus.

129. An objective lens, comprising:

a first light passing region, corresponding to a first distance from an optical axis of a beam of incident light, for passing the beam of incident light and converging the beam of incident light at an information recording plane of a first optical disk through a transparent substrate of the first optical disk having a thickness T1; and

a second light passing region, corresponding to a second distance from the optical axis of the beam of incident light, for passing the beam of incident light and converging the beam of incident light at an information recording plane of a second optical disk through a transparent substrate of the second optical disk having a thickness T2 smaller than the thickness Tl (T2<Tl).

130. An objective lens, comprising:

a first lens region, corresponding to a first numerical aperture NA1, for focusing a beam of incident light, which is radiated from a laser light source and transmits through a transparent substrate of a first information medium having a first thickness T1, to form a light spot on an information recording plane of the first information medium for the purpose of reading out information from the first information medium;

a second lens region, corresponding to a second numerical aperture NA2 higher than the first numerical aperture NA1 (NA1<NA2), for focusing the beam of incident light, which is radiated from the laser light source and transmits through a transparent substrate of a second information medium having a second thickness T2 smaller than the first thickness Tl (T2<Tl), to form a light spot on an information recording plane of the second information medium for the purpose of reading out information from the second information medium; and

a third lens region, corresponding to a numerical aperture NA4 equal to or lower than the numerical aperture NA1 (NA4≤NAl), for changing the beam of incident light radiated from the laser light source to converge the beam of incident light on the information recording plane of the first information medium through the transparent substrate of the first information medium having the first thickness T1.

131. An optical head apparatus, comprising:

a laser light source for radiating a beam of incident light;

a first information medium having an information recording plane and a transparent substrate of a first thickness Tl, a thickness of the first information medium being set to Tl;

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a second information medium having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness T1 (T2<T1), a thickness of the second information medium being set to T2; and

a light focusing optical system, in which an objective lens comprises:

a first lens region, corresponding to a numerical aperture NA1, for focusing the beam of incident light radiated from the laser light source on the information recording plane of the first information medium through the transparent substrate of the first information medium as a light spot for the purpose of reading out first information from the first information medium;

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a second lens region, corresponding to a numerical aperture NA2 higher than the numerical aperture NA1 (NA1<NA2), for focusing the beam of incident light radiated from the laser light source on the information recording plane of the second information medium through the transparent substrate of the second information medium as a light spot for the purpose of reading out second information from the second information medium; and

a third lens region, corresponding to a numerical aperture NA4 equal to or lower than the numerical aperture NA1 (NA4≤NA1), for changing the beam of incident light radiated from the laser light source to converge the beam of incident light on the information recording plane of the first information medium through the transparent substrate of the first information medium having the first thickness T1; and

a photo detector for detecting the beam of incident light, which is converged on the information recording plane of the first information medium or the information recording plane of the second information medium by the light focusing optical system and is reflect by the first information medium or the second information medium, to reproduce the first information recorded in the first information medium or the second information recorded in the second information medium.

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132. An optical disk apparatus, comprising:

a laser light source for radiating the beam of incident light having a particular wavelength;

a first information medium, having an information recording plane and a transparent substrate of a first thickness T1, for recording first information on the information recording plane, a thickness of the first information medium being set to T1;

a second information medium, having an information recording plane and a transparent substrate of a second thickness T2 smaller than the first thickness T1 (T2<T1), for recording second information on the information recording plane, a thickness of the second information medium being set to T2;

rotating means for rotating the first information medium or the second information medium;

an optical head apparatus, which comprises

a light focusing optical system, in which an objective lens comprises:

a first lens region, corresponding to a numerical aperture NA1, for focusing the beam of incident light radiated from the laser light source on the information recording plane of the first information medium through the transparent substrate of the first information medium

as a light spot for the purpose of reading out first information from the first information medium;

a second lens region, corresponding to a numerical aperture NA2 higher than the numerical aperture NA1 (NA1<NA2), for focusing the beam of incident light radiated from the laser light source on the information recording plane of the second information medium through the transparent substrate of the second information medium as a light spot for the purpose of reading out second information from the second information medium; and

a third lens region, corresponding to a numerical aperture NA4 equal to or lower than the numerical aperture NA1 (NA4≤NA1), for changing the beam of incident light radiated from the laser light source to converge the beam of incident light on the information recording plane of the first information medium through the transparent substrate of the first information medium having the first thickness T1;

focus control means for performing a first focus control of the optical head apparatus corresponding to the first thickness T1 of the first information medium and a second focus control of the optical head apparatus corresponding to the second thickness T2 of the second information medium according to the beam of incident light detected by the photo detector;

tracking control means for performing a first tracking control of the optical head apparatus corresponding to the first thickness T1 of the first information medium and a second tracking control of the optical head apparatus corresponding to the second thickness T2 of the second information medium according to the beam of incident light detected by the photo detector; and

information detecting means for judging according to the beam of incident light detected by the photo detector of the optical head apparatus, for which the first focus control and the second focus control of the focus control means and the first tracking control and the second tracking control of the tracking control means are performed, whether the beam of incident light radiated from the light source is converged at the information recording plane of the first information medium or the information recording plane of the second information medium, reproducing the first information recorded in the information recording plane of the first information medium from the beam of incident light detected by the photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the first information medium, and reproducing the second information recorded in the information recording plane of the second information medium from the beam of incident light detected by the photo detector in cases where it is judged that the beam of incident light radiated from the light source is converged at the information recording plane of the second information medium; and

moving means for moving the optical head apparatus.

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